PB-239 546

HARRIS POND, WORCHESTER COUNTY, MASSACHUSETTS, AND PROVIDENCE COUNTY, RHODE ISLAND

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Rhode Island Department of Health
Massachusetts Water Resources Commission
Rhode Island National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

HARRIS POND

WORCHESTER COUNTY, MASSACHUSETTS,

AND

PROVIDENCE COUNTY, RHODE ISLAND

EPA REGION 1

WORKING PAPER No. 27

WITH THE COOPERATION OF THE

RHODE ISLAND STATE DEPARTMENT OF HEALTH,

THE RHODE ISLAND NATIONAL GUARD,

AND THE

MASSACHUSETTS WATER RESOURCES COMMISSION

SEPTEMBER, 1974

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F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Rhode Island Division of Water Supply and Pollution Control and the Massachusetts Division of Water Pollution Control for professional involvement and to the Rhode Island National Guard for conduct of the tributary sampling phase of the Survey.

Carleton A. Maine, Chief, and James W. Fester, Principal Sanitary Engineer of the Rhode Island Division of Water Supply and Pollution Control; and Thomas C. McMahon, Director, John R. Elwood, Supervisory Sanitary Engineer, Eben Chesebrough, Senior Chemist, and Peter A. Tennant, Senior Sanitary Engineer of the Massachusetts Division of Water Pollution Control provided invaluable lake documentation and counsel during the course of the Survey.

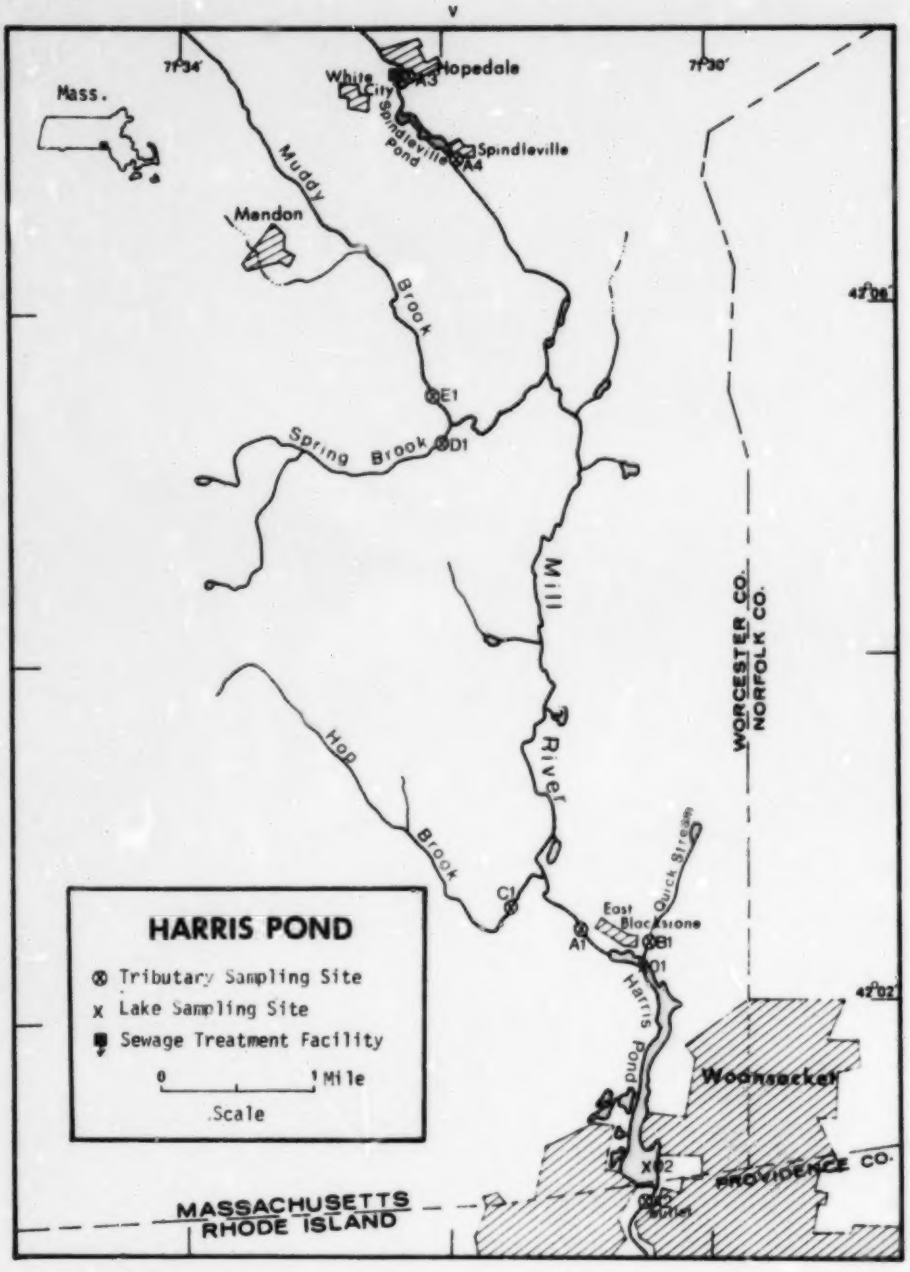
Major General Leonard Holland, the Adjutant General of Rhode Island, and Project Officer Colonel Clarence Bozar, who directed the volunteer efforts of the Rhode Island National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF RHODE ISLAND

LAKE NAME	COUNTY
Harris Pond	Providence, RI; Worchester, MA
Slatersville Reservoir	Providence, RI
Turner Reservoir	Providence, RI; Bristol, MA


HARRIS POND
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0
1 Mile
Scale
Mass.
7°34'
7°30'
42°08'
42°02'
White City
Hopedale
A3
Spindleville Pond
Spindleville
A4
Muddy Brook
Mendon
E1
Spring Brook
D1
Mill River
Hop Brook
C1
A1
East Blackstone
Quick Stream
B1
D2
D1
Harris Pond
X02
Woonsocket
PROVIDENCE CO.
WORCESTER CO.
NORFOLK CO.
MASSACHUSETTS
RHODE ISLAND

HARRIS POND

STORET NO. 2503

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Harris Pond is eutrophic. During the sampling year, the Pond exhibited marked depression or depletion of dissolved oxygen in the hypolimnion, rather high levels of nutrients, low Secchi disc transparencies, and relatively high chlorophyll a concentrations.

B. Rate-Limiting Nutrient:

The results of the algal assay indicate that Harris Pond was phosphorus limited at the time the assay sample was collected. However, the Pond data indicate that the Pond may be narrowly phosphorus limited or even nitrogen limited at times.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Harris Pond received a total phosphorus load at a rate nearly three times that proposed by Vollenweider (in press) as "dangerous" (i.e., a eutrophic rate; see page 14). It is estimated that about 76% of this load was contributed by the Hopedale wastewater treatment plant and the plating rinse discharge of the Draper Corporation textile machinery plant just upstream from Hopedale.

At this time, the Massachusetts Division of Water Pollution Control is negotiating with the community of Hopedale regarding provision of phosphorus removal with a mean effluent limit of 1 mg/l.

It is calculated that this degree of phosphorus removal at Hopedale and elimination of the Draper Corporation discharge would reduce the phosphorus loading rate of Harris Pond from the existing 58 lbs/acre/yr to 31 lbs/acre/yr, or about 3.5 $g/m^2/yr$.

While the reduced loading rate would still be somewhat greater than a eutrophic rate, it is believed that the reduction would result in improvement of the trophic condition of Harris Pond once a new phosphorus equilibrium is attained.

2. Non-point sources--The mean annual non-point phosphorus export of Quick Stream was relatively low (see page 14); and although the Mill River phosphorus export was somewhat higher, it appears that the methods used to calculate point-source phosphorus contributions to Harris Pond provided reasonable estimates.

II. INTRODUCTION

Harris Pond is a small impoundment on the Mill River in Worchester County, Massachusetts, with the dam located just across the state line in Rhode Island*. The Pond is controlled by the City of Woonsocket, Rhode Island.

The Pond serves as a water supply for Woonsocket and also provides some recreational use. Harris Pond is not considered a good fishery; but pickerel, largemouth bass, and panfish are present.

In the past, algae accumulations along the shorelines have been noted, but the State of Massachusetts has not received any complaints concerning algal blooms or excessive water weed production.

* Although the Pond is almost entirely within the State of Massachusetts, the State of Rhode Island requested the Survey study.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry:

1. Surface area: 88 acres.
2. Mean depth: 8* feet.
3. Maximum depth: 25 feet.
4. Volume: 704 acre/feet.
5. Mean hydraulic retention time: 6 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area**	Mean flow**
Mill River	28.7 mi^2	50.0 cfs
Quick Stream	2.2 mi^2	3.8 cfs
Minor tributaries & immediate drainage -	2.1 mi^2	3.8 cfs
Totals	33.0 mi^2	57.6 cfs

2. Outlet -

Mill River	33.1 $mi^{2\dagger}$	57.6 cfs

C. Precipitation††:

1. Year of sampling: 58.6 inches.
2. Mean annual: 40.3 inches.

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* Estimated (Tennant, 1974a).
** Drainage areas are accurate within ±1%; gaged flows are accurate within ±15%; and ungaged flows are accurate within ±20%.
† Includes area of Pond.
†† See Working Paper No. 1, "Survey Methods".

IV. LAKE WATER QUALITY SUMMARY

Harris Pond was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and usually from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 5 feet at station 1 and 23 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/06/72)		
Temperature (Cent.)	11.2	14.7	15.1	17.1
Dissolved oxygen (mg/l)	0.0	5.6	3.4	12.0
Conductivity (μmhos)	128	137	135	155
pH (units)	6.3	7.2	6.6	8.6
Alkalinity (mg/l)	12	16	17	18
Total P (mg/l)	0.033	0.066	0.070	0.123
Dissolved P (mg/l)	0.013	0.030	0.023	0.076
NO_2 + NO_3 (mg/l)	0.070	0.261	0.180	0.530
Ammonia (mg/l)	0.100	0.620	0.170	2.820
		ALL VALUES		
Secchi disc (inches)	18	30	36	40

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
08/01/72	1. Gloeocapsa	1,138
	2. Dinobryon	264
	3. Schroederia	188
	4. Anabaena	106
	5. Scenedesmus	98
	Other genera	429
	Total	2,223
10/06/72	1. Fragilaria	2,415
	2. Melosira	1,509
	3. Dictyosphaerium	1,472
	4. Flagellates	1,207
	5. Cyclotella	1,019
	Other genera	3,586
	Total	11,208

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/04/72	01	2.5
	02	1.0
08/01/72	01	47.2
	02	2.5
10/06/72	01	10.8
	02	13.7

* The June phytoplankton sample was lost in shipment.

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	0.545	7.5
0.006 P	0.026	0.545	14.0
0.012 P	0.032	0.545	11.5
0.024 P	0.044	0.545	13.0
0.060 P	0.080	0.545	12.5
0.060 P + 10.0 N	0.080	10.545	60.4
10.0 N	0.020	10.545	6.4

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Harris Pond was relatively high at the time the sample was collected.

The addition of the first increment of phosphorus stimulated an increase in yield which indicates Harris Pond was phosphorus limited (note that the addition of only nitrogen resulted in a yield not significantly different than the control yield). However, further increments of orthophosphorus did not result in additional increases in yield, indicating the Pond was narrowly phosphorus limited at the time the sample was collected.

Pond data also indicate Harris Pond was phosphorus limited, especially during the June and October sampling periods (nitrogen/phosphorus ratios were 29/1). However, Pond data from the

August sampling period indicate the limiting nutrient probably was nitrogen (the nitrogen/phosphorus ratio at station 1 was 9/1 and at station 2 averaged 13/1).

D. Trophic Condition:

During the sampling year, Harris Pond was characterized by marked depression or depletion of dissolved oxygen in the hypolimnion, rather high nutrient levels, poor Secchi disc transparencies, and relatively high chlorophyll a values.

Historically, the Pond has experienced some accumulations of algae along the shorelines, and some rooted aquatic weeds grow in the near-shore areas. However, the State of Massachusetts has not received any complaints concerning algal blooms or excessive aquatic weed growth. In part, this may be due to the use of copper sulfate by the City of Woonsocket in this water-supply reservoir (Fester, 1974).

Personnel of the Massachusetts Division of Water Pollution Control consider Harris Pond to be eutrophic (Tennant, 1974a).

V. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Rhode Island National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of March and April when two samples were collected. Sampling was begun in August, 1972, and was completed in July, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the New England District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean annual concentrations in Hop Brook at station C-1 and the mean annual ZZ flow.

The discharges of the Hopedale wastewater treatment plant and the Draper Corporation plant were not sampled during the Survey, and the phosphorus loads attributed to these sources were estimated as outlined in Appendix D. The nitrogen load from the Hopedale plant was determined by the difference in load in the Mill River from station A-3 (above the plant) to station A-4 (below the plant); the nitrogen load from the Draper Corporation is based on information provided by the Massachusetts Division of Water Pollution

Control (Tennant, 1974b). In the nitrogen loading table, the load given for the Mill River is that measured at station A-1 minus the point-source loads.

As noted before, Harris Pond serves as a water supply for the City of Woonsocket. The nutrient losses from the system through this use were not determined. Only the estimates of net annual phosphorus and nitrogen accumulations would be affected in any case.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Hopedale	2,500	trickling filter	0.300	Mill River

2. Known industrial** -

Name	Product	Treatment	Mean Flow (mgd)	Receiving Water
Draper Corp.	textile machinery	none (plating rinse waters)	?	Mill River

* Tennant, 1973.
** Tennant, 1974b.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Mill River	1,770*	20.8
Quick Stream	110	1.3
b. Minor tributaries & immediate drainage (non-point load) -	120	1.4
c. Known municipal STP's -		
Hopedale	5,390*	63.3
d. Septic tanks - Unknown	-	-
e. Known industrial** -		
Draper Corporation	1,110*	13.1
f. Direct precipitation† -	10	0.1
Total	8,510	100.0

2. Outputs -

Lake outlet - Mill River 5,560

3. Net annual P accumulation - 2,950 pounds

* Estimated; see Appendix D.
** Tennant, 1974b.
† Estimated; see Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Mill River	59,360	61.5
Quick Stream	3,600	3.7
b. Minor tributaries & immediate drainage (non-point load) -	3,760	3.9
c. Known municipal STP's -		
Hopedale	26,380	27.3
d. Septic tanks - Unknown	-	-
e. Known industrial* -		
Draper Corporation	2,650	2.7
f. Direct precipitation† -	850	0.9
Total	96,600	100.0

2. Outputs -

Lake outlet - Mill River 93,440

3. Net annual N accumulation - 3,160 pounds

* Tennant, 1974b.
† See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Mill River	62*	2,068
Quick Stream	50	1,636

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	58.0	33.5	1,097.7	35.9
grams/m^2/yr	6.50	3.76	123.0	4.0

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Harris Pond:

"Dangerous" (eutrophic rate)	2.30
"Permissible" (oligotrophic rate)	1.15

* Estimated; see Appendix D.

VI. LITERATURE REVIEWED

Anonymous, 1974. Blackstone River, 1973 water quality survey data. Publ. No. 6995-175-57-11-73-CR, MA Water Resources Comm., Westborough.

Fester, James W., 1974. Personal communication (water supply use of Harris Pond). RI Divn. Water Supply & Pollution Control, Providence.

Tennant, Peter A., 1973. Wastewater treatment plant questionnaire (contributing population and description of Hopedale STP). MA Divn. Water Pollution Control, Westborough.

_____, 1974a. Personal communication (characteristics, uses, and trophic condition of Harris Pond). MA Divn. Water Pollution Control, Westborough.

_____, 1974b. Personal communication (description of Draper Corp. discharge and nutrient loads). MA Divn. Water Pollution Control, Westborough.

Vollenweider, Richard A., (in press). Input-output models. Schweiz A. Hydrol.

TRIBUTARY FLOW INFORMATION FOR MASSACHUSETTS 8/8/74

LAKE CODE 2503 HARRIS POND

TOTAL DRAINAGE AREA OF LAKE 33.10

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2503A1	28.70	62.60	71.50	103.00	98.70	60.60	33.60	16.50	17.00	21.50	24.70	43.60	56.50	50.81
2503A2	33.10	72.20	82.40	118.00	105.00	69.80	38.70	19.10	19.70	24.80	28.50	50.30	65.20	57.64
2503B1	2.21	4.80	5.50	7.90	7.00	4.70	2.60	1.30	1.30	1.70	1.90	3.40	4.40	3.86
2503ZZ	2.20	4.80	5.50	7.90	7.00	4.70	2.60	1.30	1.30	1.70	1.90	3.40	4.40	3.86

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 33.10
SUM OF SUB-DRAINAGE AREAS = 33.11

TOTAL FLOW IN = 694.80
TOTAL FLOW OUT = 693.70

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2503A1	8	72	21.80	30	15.80				
	9	72	26.90	24	37.90				
	10	72	54.80	14	50.50				
	11	72	150.00	5	50.50				
	12	72	189.00	2	197.00				
	1	73	110.00	7	110.00				
	2	73	121.00	3	551.00				
	3	73	68.20	11	75.80	25	53.10		
	4	73	122.00	7	126.00	21	60.00		
	5	73	73.40	9	64.00				
	6	73	36.00						
	6	73	36.00	10	26.10				
	7	73	42.30	7	74.00				
2503A2	8	72	25.20	30	10.20				
	9	72	31.00	24	43.70				
	10	72	63.30	14	67.50				
	11	72	173.00	5	50.30				
	12	72	218.00	2	227.00				
	1	73	126.00	7	127.00				
	2	73	139.00	3	636.00				
	3	73	78.10	11	87.40	25	61.20		
	4	73	141.00	7	145.00	21	69.20		
	5	73	84.50	9	74.50				
	6	73	41.40						
	6	73	41.40	10	30.10				
	7	73	48.90	7	85.50				

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TRIBUTARY FLOW INFORMATION FOR MASSACHUSETTS 8/8/74

LAKE CODE 2503 HARRIS POND

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2503R1	8	72	1.70	30	1.20				
	9	72	2.10	24	2.90				
	10	72	4.20	14	4.50				
	11	72	11.70	5	3.90				
	12	72	14.70	2	15.20				
	1	73	8.40	7	8.50				
	2	73	9.30	3	42.40				
	3	73	5.20	11	5.80	25	4.10		
	4	73	9.40	7	9.70	21	4.60		
	5	73	5.70	9	5.00				
	6	73	2.80						
	6	73	2.80	10	2.00				
	7	73	3.30	7	5.70				
2503ZZ	8	72	1.70						
	9	72	2.10						
	10	72	4.20						
	11	72	11.70						
	12	72	14.70						
	1	73	8.40						
	2	73	9.30						
	3	73	5.20						
	4	73	9.40						
	5	73	5.70						
	6	73	2.80						
	7	73	3.30						

17

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/08/09

250301
42 02 00.0 071 30 18.0
HARRIS POND
25 MASSACHUSETTS

11EPALES 2111202
3 0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/04	13 20	0000	21.4	8.0	40	100	6.30	11	0.120	0.130	0.060	0.002K
72/08/01	18 45	0000		11.6	36	110	8.60	10	0.180	0.120	0.084	0.032
72/10/06	16 05	0000			19	143	7.35	17	0.380	0.120	0.073	0.028
	16 05	0005	15.1	9.2		135	6.60	17	0.530	0.170	0.085	0.032

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/04	13 20	0000	2.5J
72/08/01	18 45	0000	47.2J
72/10/06	16 05	0000	10.8J

K* VALUE KNOWN TO BE LESS THAN INDICATED

J* VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/08/09

250302
42 01 04.0 071 30 28.0
HARRIS POND
25 MASSACHUSETTS

11EPALES
3

2111202
0025 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/04	13 35	0000	20.2	8.0		90	6.30	12	0.150	0.120	0.034	0.020
	13 35	0015	14.7	5.4		100	6.30	13	0.220	0.190	0.026	0.015
	13 35	0020	10.4	6.2		100	6.10	13	0.210	0.280	0.015	0.012
72/08/01	18 15	0000			36	105	8.70	10	0.120	0.090	0.052	0.020
	18 15	0004	25.7	7.2		110	6.40	10K	0.210	0.170	0.028	0.026
	18 15	0008	21.7	2.4		105	6.10	10K	0.120	0.100	0.051	0.024
	18 15	0015	16.0	0.4		105	5.90	10K	0.040	1.000	0.103	0.067
	18 15	0021	11.3	0.4		105	5.90	10K	0.040	0.980	0.096	0.064
72/10/06	15 30	0000			18	128	8.65	16	0.150	0.100	0.041	0.015
	15 30	0004	17.1	12.0		130	8.60	17	0.160	0.120	0.034	0.013
	15 30	0015	15.4	3.4		130	6.25	18	0.180	0.590	0.033	0.020
	15 30	0019	14.7	3.3		140	6.30	16	0.360	0.420	0.070	0.023
	15 30	0023	11.2	0.0		155	6.35	12	0.070	2.820	0.123	0.076

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/04	13 35	0000	1.0J
72/08/01	18 15	0000	2.5J
72/10/06	15 30	0000	13.7J

K* VALUE KNOWN TO BE LESS THAN INDICATED

J* VALUE KNOWN TO BE IN ERROR

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APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/08/08

2503A1 LS2503A1
42 02 30.0 071 31 00.0
MILL RIVER
25 7.5 BLACKSTONE
I/HARRIS POND MA
SUMMER ST BRDG W OF E BLACKSTONE MA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	10 50		0.590	0.775		0.048	0.138
72/09/24	11 15		0.530	0.750	0.336	0.052	0.140
72/10/14	13 15		0.528	0.700	0.354	0.050	0.120
72/11/05	11 30		0.370	0.550	0.200	0.056	0.126
72/12/02	13 30		0.200	0.440	0.044	0.012	0.034
73/01/07	14 30		0.260	0.350	0.084	0.013	0.030
73/02/03	13 30		0.200	0.500	0.075	0.025	0.095
73/03/11	12 45		0.240	0.500	0.130	0.028	0.060
73/03/25	09 00		0.300	0.340	0.094	0.034	0.055
73/04/07	13 30		0.180	0.660	0.075	0.022	0.045
73/04/21	09 15		0.198	0.630	0.097	0.025	0.070
73/05/09	13 30		0.231	0.630	0.210	0.039	0.080
73/06/10	10 30		0.480	0.480	0.100	0.069	0.135
73/07/07	09 05		0.176	0.780	0.089	0.038	0.080

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STORET RETRIEVAL DATE 74/08/08

2503A2 LS2503A2
42 01 00.0 071 30 30.0
MILL RIVER
25 7.5 BLACKSTONE
O/HARRIS POND MA
ST HWY 114 BRDG IN WOONSOCKET
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	10 06		0.072	0.785	0.005K	0.017	0.048
72/09/24	11 05		0.263	0.925	0.093	0.013	0.066
72/10/14	13 00		0.370	1.100	0.370	0.015	0.066
72/11/05	11 17		0.410	0.850	0.240	0.025	0.073
72/12/02	12 30		0.200	0.340	0.048	0.010	0.037
73/01/07	13 20		0.336	0.340	0.054	0.018	0.025
73/02/03	13 20		0.330	0.380	0.120	0.022	0.060
73/03/11	11 40		0.290	0.310	0.078	0.018	0.045
73/03/25	09 15		0.300	0.390	0.060	0.014	0.035
73/04/07	13 15		0.252	0.290	0.044	0.012	0.030
73/04/21	09 15		0.200	0.460	0.013	0.021	0.045
73/05/09	13 00		0.240	0.580	0.052	0.016	0.045
73/06/10	12 12		0.310	0.320	0.066	0.024	0.055
73/07/07	09 15		0.180	0.720	0.066	0.025	0.055

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K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/08/08

2503A3 LS2503A3
42 07 30.0 071 32 00.0
MILL RIVER
25 7.5 BLACKSTONE
I/HARRIS POND MA
BRDG JUST ABOV HOPEDALE STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	13	28	0.280	0.950	0.069	0.078	0.260
72/09/24	10	35	0.140	0.450	0.198	0.010	0.058
72/11/05	12	09	0.210	0.650	0.252	0.026	0.075
72/12/02	14	00	0.170	0.680	0.140	0.031	0.067
73/01/07	13	30	1.940	0.100K	0.014	0.007	0.010
73/02/03	14	05	0.170	0.250	0.045	0.007	0.030
73/03/11	12	00	0.115	0.290	0.048	0.022	0.025
73/03/25	09	15	0.150	0.350	0.072	0.018	0.045
73/04/07	13	30	0.550	1.150	0.590	0.273	0.375
73/04/22	09	05	0.092	0.370	0.048	0.011	0.035
73/05/09	14	00	0.530	1.210	0.100	0.042	0.183
73/06/10	13	00	0.110	0.140	0.033	0.042	0.210
73/07/07	09	20	0.042	0.520	0.040	0.007	0.025

24

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/08/08

2503A4 LS2503A4
42 07 00.0 071 32 00.0
MILL RIVER
25 7.5 BLACKSTONE
T/HARRIS POND
MILL ST BRDG BELO HOPEDALE STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	13	12	0.551	2.060	1.000L	0.310	0.660
72/09/24	10	22	0.235	0.800	0.450	0.115	0.200
72/10/14	15	00	0.470	1.850	0.280	0.280	0.490
72/11/05	11	00	0.410	1.180	0.730	0.200	0.353
72/12/02	15	00	0.126	0.290	0.050	0.005K	0.025
73/01/07	14	00	1.940	0.100K	0.005K	0.006	0.006
73/02/03	14	15	0.190	0.500	0.105	0.018	0.060
73/03/11	12	30	0.180	0.440	0.160	0.052	0.090
73/03/25	09	20	0.231	0.660	0.290	0.100	0.150
73/04/07	14	45	0.490	1.100	0.510	0.240	0.340
73/04/22	09	10	0.105	0.750	0.340	0.060	0.115
73/05/09	14	45	0.540	0.720	0.086	0.036	0.105
73/06/10	13	30	0.102	0.100K	0.020	0.037	0.190
73/07/07	09	15	0.068	0.690	0.170	0.042	0.090

25

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/08/08

250381 LS250381
42 02 30.0 071 30 30.0
QUICK STREAM
25 7.5 BLACKSTONE
T/HARRIS POND MA
ELM ST BRDG SE OF E BLACKSTONE MA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	11 00		0.169	0.300	0.082	0.006	0.013
72/09/24	11 30		0.156	0.100K	0.044	0.005K	0.012
72/10/14	13 45		0.123	0.200	0.057	0.005K	0.005
72/11/05	11 50		0.156	0.200	0.060	0.005K	0.007
72/12/02	12 00		0.189	0.180	0.013	0.005K	0.015
73/01/07	13 45		0.260	0.630	0.024	0.010	0.010
73/02/03	14 00		0.220	0.190	0.060	0.006	0.020
73/03/11	12 15		0.170	0.420	0.028	0.010	0.015
73/03/25	09 30		0.170	0.160	0.027	0.007	0.010
73/04/07	14 00		0.126	0.350	0.021	0.011	0.020
73/04/21	09 30		0.120	0.210	0.019	0.005K	0.020
73/05/09	14 00		0.140	0.360	0.052	0.006	0.020
73/06/10	10 45		0.170	0.840	0.072	0.010	0.020
73/07/07	09 15		0.126	0.260	0.048	0.007	0.015

98

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/08/08

2503C1 LS2503C1
42 02 30.0 071 31 30.0
HOP BROOK
25 7.5 BLACKSTONE
T/HARRIS POND MA
FARM ST BRDG WNW OF E BLACKSTONE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	10 35		0.455	1.050	0.180	0.009	0.036
72/09/24	11 20		0.169	0.350	0.154	0.012	0.022
72/10/14	13 15		0.093	0.500	0.138	0.005K	0.012
72/11/05	11 45		0.042	0.300	0.061	0.006	0.011
72/12/02	12 50		0.016	0.440	0.015	0.005K	0.012
73/01/07	13 35		0.032	0.200	0.022	0.006	0.006
73/02/03	13 35		0.025	0.250	0.017	0.005K	0.010
73/03/11	12 05		0.025	0.350	0.023	0.008	0.015
73/03/25	09 25		0.028	0.170	0.013	0.005	0.005
73/04/07	13 30		0.010K	0.170	0.007	0.005K	0.010
73/04/21	09 30		0.025	0.290	0.019	0.009	0.010
73/05/09	13 15		0.036	0.600	0.063	0.005K	0.015
73/06/10	12 25		0.050	0.560	0.073	0.009	0.030
73/07/07	09 30		0.038	0.655	0.032	0.007	0.015

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/08/08

250301 LS250301
42 05 30.0 071 32 00.0
SPRING BROOK
25 7.5 BLACKSTONE
T/HARRIS POND MA
PROVIDENCE ST BRDG SSE OF MENDON MA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	12 45		0.156	0.400	0.012	0.005K	0.012
72/09/24	10 10		0.100	2.650	0.430	0.032	0.063
72/10/14	12 40		0.022	0.400	0.084	0.005K	0.010
72/11/05	12 45		0.036	0.350	0.076	0.006	0.009
72/12/02	13 35		0.083	0.380	0.020	0.010	0.011
73/01/07	13 30		0.115	0.560	0.018	0.005K	0.005K
73/02/03	13 05		0.110	0.280	0.007	0.005K	0.015
73/03/11	13 15		0.046	0.920	0.072	0.008	0.015
73/03/25	09 22		0.018	0.150	0.015	0.005K	0.005K
73/04/07	13 40		0.010K	0.140	0.007	0.005K	0.005K
73/04/21	09 45		0.010K	0.300	0.019	0.005K	0.005K
73/05/09	13 30		0.040	0.280	0.017	0.005K	0.015
73/06/10	10 00		0.054	0.700	0.084	0.008	0.025
73/07/07	09 15		0.046	0.840	0.072	0.006	0.010

K VALUE KNOWN TO BE LESS THAN INDICATED

28

STORET RETRIEVAL DATE 74/08/08

2503E1 LS2503E1
42 05 30.0 071 32 00.0
MUDDY BROOK
25 7.5 BLACKSTONE
T/HARRIS POND
HARTFORD AVE BRDG SE OF HENDON
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/08/26	12 55		0.471	0.400	0.022	0.010	0.029
72/09/24	10 00		0.098	0.200	0.052	0.006	0.023
72/10/14	12 50		0.234	0.375	0.084	0.005K	0.022
72/11/05	12 50		0.290	0.250	0.063	0.007	0.018
72/12/02	13 40		0.360	0.340	0.008	0.013	0.022
73/01/07	13 35		0.410	0.540	0.027	0.007	0.010
73/02/03	13 10		0.300	0.440	0.028	0.010	0.035
73/03/11	13 25		0.450	1.400	0.115	0.014	0.030
73/03/25	09 26		0.390	0.270	0.028	0.007	0.010
73/04/07	14 05		0.290	0.320	0.029	0.007	0.010
73/04/21	09 50		0.250	0.315	0.031	0.009	0.020
73/05/09	13 35		0.420	0.560	0.060	0.015	0.060
73/06/10	10 05		0.310	0.400	0.075	0.009	0.040
73/07/07	09 20		0.260	0.700	0.063	0.011	0.020

K VALUE KNOWN TO BE LESS THAN INDICATED

29

APPENDIX D

HOPEDALE and DRAPER CORP.
PHOSPHORUS LOADS

During the sampling year, the phosphorus load measured in the Mill River at station A-4 (flow adjusted) was 12,990 lbs, or over 4,000 lbs more than the 8,270 lb load measured at the Harris Pond inlet station (A-1; see map, page v). This loss is attributed to sedimentation and/or biological assimilation in the intervening seven or so miles of the Mill River.

Because of this loss, it was necessary to calculate point and non-point phosphorus contributions indirectly, and the following rationale was used to estimate the phosphorus loads reaching Harris Pond:

1. The mean of the total phosphorus concentrations in Quick Stream (B-1), Hop Brook (C-1), Spring Brook (D-1), and Muddy Brook (E-1) = 0.018 mg/l during the sampling year (as far as is known, none of these streams receives point-source nutrients and thus are believed to be representative of Mill River drainage non-point nutrient contributions).

2. Using the mean Mill River flow at A-1 (50.0 cfs) and the mean total phosphorus concentration in the above streams, the calculated non-point load in the Mill River at A-1 = 1,770 lbs P/yr.

3. The phosphorus load measured at A-1 = 8,270 lbs minus the 1,770 lbs non-point load = 6,500 lbs P/yr due to the two point sources.

4. The total point-source load at the point of discharge = 6,230 lbs (Hopedale) plus 1,280 lbs (Draper Corp.*) = 7,510 lbs P/yr.

5. Then the portion of the Hopedale load reaching the Pond = 6,230/7,510 X 6,500 = 5,390 lbs P/yr (rounded).

6. And the portion of the Draper Corp. load reaching the Pond = 1,280/7,510 X 6,500 = 1,110 lbs P/yr (rounded).

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* Tennant, 1974b.